T53-L-703 MILITARY QUALIFICATION TEST PROGRAM

Avco Lycoming Division

Prepared for:

Army Aviation Materiel Command

June 1975

AVCO LYCOMING DIVISION
STRATFORD, CONNECTICUT

REPORT NO. LYC 74-17.3

T53-L-703 MILITARY QUALIFICATION TEST PROGRAM FINAL STATUS REPORT

Covering September 1974 Through 31 May 1975

DAAJ01-73-C-0390

June 1975

AVCO LYCOMING DIVISION

ENGINEERING SUMMARY

Proposal No. 4284.5

DATE	REVISED
3/18/74	5/31/75

PROGRAM TITLE	PRIORITY	PROGRAM #
T53-L-703 Military Qualification Test Program	P	F004

PROBLEM DEFINITION

New engine models require testing to evaluate design concept, to endurance and flight test hardware so as to insure satisfactory mission effectiveness, and to demonstrate adequacy for release to production.

INCIDENTS	LISTS
Field	N/A
Development	N/A

MODELS AFFECTED
T53-L-703

ENGINEERING PROGRAM

Avco Lycoming shall furnish the personnel, services, facilities, equipment and material necessary to perform development testing leading to military qualification of the T53-L-703 engine. The work will be performed in five tasks as follows:

Task I -- Mission Profile Testing
Task II -- Flight Test Support
Task III -- Sand and Dust Test
Task IV -- Altitude Performance Test
Task V -- Military Qualification Testing

Task I -- Mission Profile Testing

A total of 2000 hours of Mission Profile Testing will be conducted to demonstrate the reliability of the T53-L-703 engine. Four engines will be utilized to complete the proposed program which includes the following tests:

PLANNED PROG COST $ 2,085,600		
PLANNED PROG COST CY $		
EST. COST TO DATE 102%		
EFFECTS	INCR/DECR YES/NO	N/A UNESTAB
Model Specification	N/A	
Performance	N/A	
Weight	N/A	
Overhaul Interval	N/A	
Reliability	N/A	
Maintainability	N/A	
Installation Interface	N/A	
Interchangeability	N/A	
AGE	N/A	
SCHEDULE	Planned	Actual
Start	4/74	
Drawings	N/A	
Hardware	7/74	
Testing Complete	11/74	
ECP/EO Submit	10/74	
ECP/EO Approved	N/A	
Production Intro	N/A	
Kit Ordered	N/A	
Kit Lead Time	N/A	

Estimated Full Scale Engine Test Hours 2500

Estimated Component Test Hours N/A

COST PER ENGINE: Current Hardware $ N/A Redesigned Hardware $ N/A

ENGINE COST	TOOLING COST	FACILITIES COST	KIT COST	MODEL	QTY
N/A	N/A	N/A	N/A	T53-L-703	N/A

* Task I -- Mission Profile Testing (continued)

a. 450 hours of Mission Profile Testing on the first available engine.
b. 200 hours of Mission Profile Testing on the second engine.
c. 1000 hours of Mission Profile Testing on the third engine.
d. 350 hours of Mission Profile Testing on the fourth engine.

The engine conversion and test schedules are shown on the proposed T53-L-703 qualification program chart provided as Attachment "B". As shown on the schedule, the 1000-hour test engine will be inspected in the test cell after completion of 400 hours of testing. The Mission Profile Test program is scheduled for completion by 31 October 1974.

Task II -- Flight Test Support

Three (3) GFM T53-L-13B engines will be converted to the T53-L-703 configuration and delivered to the U. S. Army for shipment to Bell Helicopter Company during the fifth and sixth months after contract award as indicated in Attachment "B".

Lycoming shall furnish technical and logistics support to BHC beginning with delivery of the first prototype T53-L-703 engine and ending 14 months after date of contract. Logistics support shall be those improved parts and assemblies which are peculiar to the T53-L-703 configuration.

Task III -- Sand and Dust Test

Following the completion of Mission Profile Testing under Task I, an engine will be inspected, reassembled and outfitted with a P/N 1-010-500-08 Particle Separator. This system will be subjected to a sand and dust test in accordance with Paragraph 4.5.7 of AV-E-8593B. A test specification for this activity will be prepared. The schedule for this task is shown on Attachment "B".

Task IV -- Altitude Performance Test

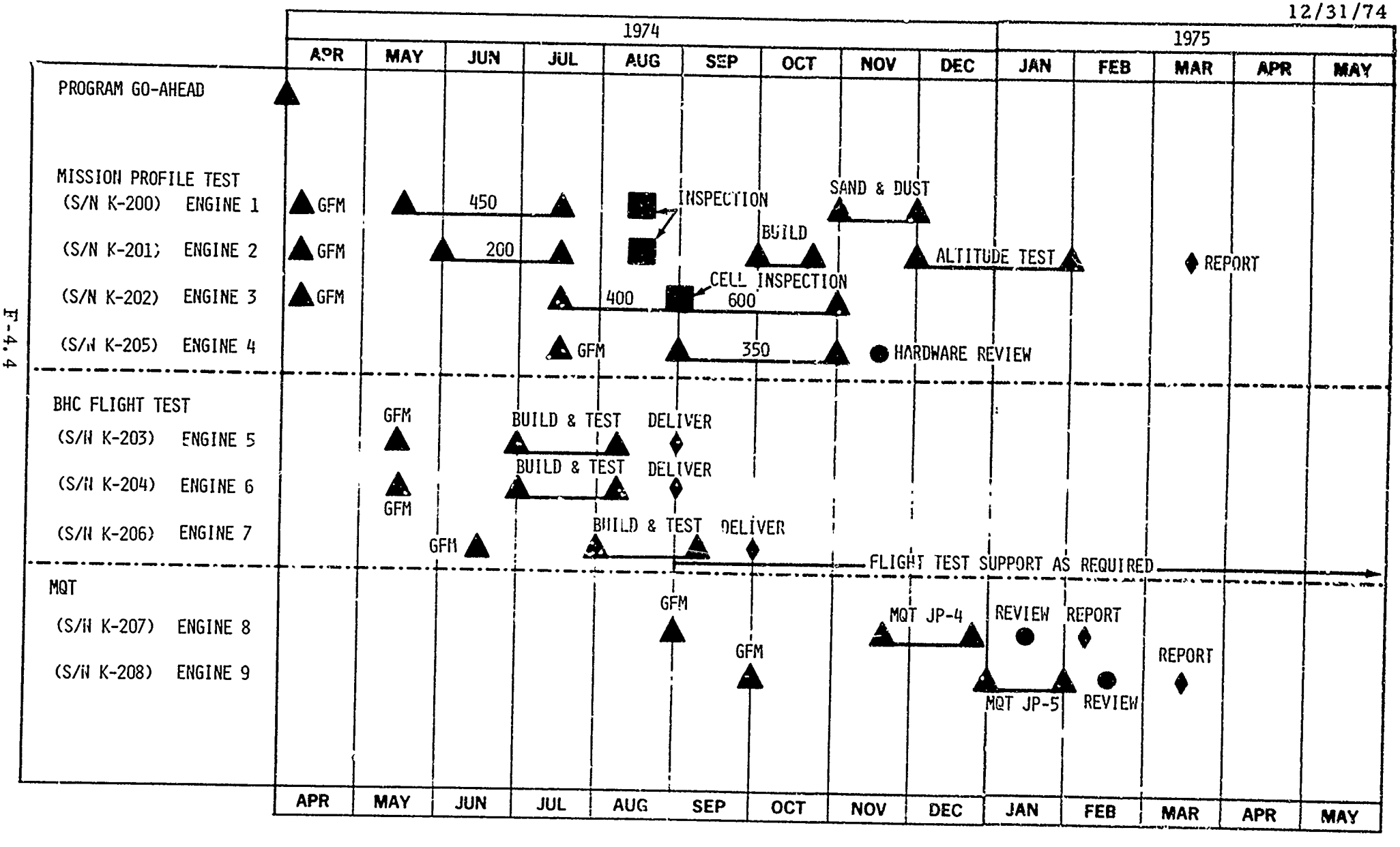
Following completion of Mission Profile Testing, a second engine will be inspected, reassembled and instrumented in preparation for altitude performance testing. The engine will be outfitted with a test waterbrake mounted in an engine test stand and shipped to NAPTC, Trenton, N.J. for the conduct of an altitude performance test in accordance with Paragraph 4.5.2 of AV-E-8593B. A test specification for this activity will be prepared. Shipment of this unit is scheduled for 31 October 1974 as shown on Attachment "B".

Task V -- Military Qualification Testing

Two (2) new GFE T53-L-13B engines will be updated to the current T53-L-13B configuration utilizing the GFM parts list in Attachment "A" and converted to the T53-L-703 configuration for the conduct of two official 150-hour endurance tests. The schedule for fabrication and testing of these engines is as shown on Attachment "B". The 150-hour endurance test cycle shall be as specified in reference a) model specification. One test engine shall be run using MIL-L-7808 oil and JP-4 fuel, while the second engine will be tested utilizing MIL-L-23699 oil and JP-5 fuel. This task is scheduled for completion by 1 January 1975 with the final report submittal by 15 March 1975.

T53-L-703 MILITARY QUALIFICATION TEST PROGRAM

*Updated 12/31/74



Program T53F004

T53-L-703 Military Qualification Test Program

Activity and Status

This program is being conducted and reported on in accordance with the program plan as revised on 19 July 1974.

TASK I -- Mission Profile Testing

a. 450-Hour Mission Profile Test

April Through August 1974

T53-L-13B Engine LE 21402 (GFE) was converted to the T53-L-703 configuration and redesignated as Engine K-200.

Under the original program plan, Engine K-200 was assigned to perform a 1000-hour mission profile test. The first 400-hour portion of the test was completed and the scheduled field-type inspection was performed in the test cell in early July.

At 454 total endurance hours, on 13 July, failure of the power take-off water brake was discovered. This failure caused water contamination in the engine oil system. Since the exact time of failure is not known, the period of time that the engine ran with contamination could not be defined. Engine disassembly disclosed no mechanical damage to engine components, however, static exposure to the water contamination incurred corrosive attack on some bearings, necessitating their replacement. This occurrence destroyed the validity of this engine as the 1000-hour endurance sample.

On 19 July 1974 a revision to the project work statement was recommended, in view of the above test equipment failure, and in the interest of timely program completion. This revision, pertaining to the rescheduling of Task I, was approved and the revised program plan is shown in the Engineering Summary.

The revised assignment of Engine K-200 is a 450-hour Mission Profile Test, followed by inspection, replacement of water damaged components, and subsequent reassembly for Sand and Dust Testing to be run in November, 1974.

The status of Engine K-200 as of the end of this reporting period is as follows:

1.) 450-hours of Mission Profile Testing completed.

2.) General visual post-test inspection and photography of engine components has been completed.

3.) Detail component inspection and and analysis has been initiated.

A pre-endurance calibration of the engine demonstrated compliance with all model specification guarantees. No engine problems developed during the endurance test. A post-test calibration check taken after the first 400 hours of endurance running demonstrated performance to be essentially as originally calibrated.

The general visual inspection of the engine after test indicated no wear, temperature, or mechanical damages. (Excluding water exposure effects.) Components were in excellent condition and were suitable for further extended operation.

September Through December 1974

Detail component inspection and analysis were completed on Engine K-200 after completion of the 450 hours of Mission Profile Testing. The only significant distress exhibited (excluding water exposure effects) was a light running interference at the rear tip ("C" location) of the centrifugal impeller vanes against the magnesium impeller housing surface. Although no performance effects were apparent from this rub, operational deflections which closed the built-in static clearance (.062-.066) are indicated. The introduction of the steel (AMS 5355) centrifugal housing, as will be incorporated in the qualification engines, is designed to minimize housing deflection and eliminated running interference.

The main shaft (Pos. No. 1, 2, 3, 4 & 21) bearings and all power reduction gear assembly bearings (Pos. No. 40, 43, 44 & 45) exhibited corrosion resulting from water exposure as discribed in the previous reporting period. These bearings were replaced and the engine was rebuilt for assignment in the sand and dust test which is reported on under Task III.

JANUARY THROUGH MAY 1975

The 450- Hour Mission Profile Test was successfully completed during the previous reporting period. Report No. LYC 75-37, 2000-Hour Mission Profile Test Performed on T53-L-703 Engine K-200, K-201, and K-205, will be issued in early June 1975 and will constitute completion of action required under this project task.

b. 200-Hour Mission Profile Test

April Through August 1974

T53-L-13B (GFE) Engine LE 21391 was converted to the T53-L-703 configuration and re-designated as Engine K-201.

In mid July this engine completed 200 hours of Mission Profile Testing as assigned under the revised program plan. This engine will receive post test inspection and will be reassembled and submitted for altitude testing scheduled to be run in December, 1974.

The status of Engine K-201 as of the end of this reporting period is as follows:

1.) 200-hours Mission Profile Testing completed.

2.) General Visual Post Test Inspection and photography has been accomplished.

3.) Detail Component Inspection and analysis have been initiated.

A pre-endurance test calibration of this engine demonstrated compliance with all model specification guarantees. The engine successfully completed its 200-hour endurance test without problems, and a post-test calibration check demonstrated essentially the same performance as the original calibration.

The general visual inspection of the engine after test revealed no wear temperature or mechanical damages. The excellent condition of engine components indicated fitness for further extended operation.

September Through December 1974

Detail component inspection and analysis were completed on Engine K-201 after completion of the 200 hours of Mission Profile Testing. The only significant distress exhibited was a very light centrifugal impeller rear tip rub. This engine also had a magnesium impeller housing incorporated. Also, the non-structural gas passage outer shroud of the exhaust diffuser had a radial crack which extended approximately 130° circumferentially, but separation was not suffi-

cient to restrict gas passage. The exhaust diffuser had been transferred from other previous house engine durability and extensive accelerated aging test assignments and the cracking condition is attributed to usage rather than T53-L-703 application. Weld repair per standard overhaul procedure was performed and the exhaust diffuser was returned to Engine K-201 for further service.

Engine K-201, having been found fit for further extended operation, was reassembled for its schedule assignment, Altitude Test, reported on in Task IV.

JANUARY THROUGH MAY 1975

The 200-Hour Mission Profile Test was successfully completed during the last reporting period. Report No. LYC 75-37 "2000-Hour Mission Profile Test Performed on T53-L-703 Engines K-200, K-201, K-202, and K-205" will be issued in early June 1975 and will constitute completion of action required under this project task.

c. 1000-Hour Mission Profile Test

April Through August

T53-L-13B (GFE) Engine LE 23175 was converted to the T53-L-703 configuration and re-designated as K-202.

Engine K-202 was assigned to perform this task section under the revised program schedule, and as of this reporting period, has completed the first 400-hour leg of the 1000-hour Mission Profile Test.

Initial testing after conversion exhibited a vibration problem in the N_2 rotating system. Disassembly, inspection, and check balance investigation of components produced only a suspected power turbine through bolt runout problem as possible cause for the excessive vibration. Rebuild and test with a replacement through bolt failed to repeat the exhibited high vibration point. However, subsequent testing with reinstallation of the original through bolt also failed to reproduce the initial vibration irregularity. The problem was resolved without definite determination of cause.

The status of Engine K-202 as of the end of this reporting period is as follows:

1.) The first 400-hour portion of the 1000-hour Mission Profile Test has been run.

2.) Cell inspection after 400 hours was accomplished without deviation.

3.) The final 600-hour test portion has been initiated and is in progress.

One part replacement was made in Engine K-202 after completion of the first 400-hour test portion. The First Stage Gas Producer Turbine was replaced with that which had run 450 hours in Engine K-200. The reason for this replacement was to obtain maximum running time on the First Stage G.P. Wheel which had optimized updated configuration. This Turbine Wheel has C101 blades with solid cast tip configuration, and was the only piece available which had full incorporation of these improvements.

A pre-endurance calibration of the engine exhibited compliance with all Model Specification guarantees. No problems developed during the first 400-hour portion of the test program.

The test cell hot-end inspection after 400 hours showed no discrepancies. Engine components were in excellent condition suitable for further extended operation.

September Through December 1974

After completion of the first 400 hours of testing and satisfactory cell hot end inspection, Engine K-202 was reassembled for continuation of the 1000 hour test program.

During the early stages of the final 600 hour test leg, an obviously false T7 temperature indication was experienced. The reason for this problem was found to be discontinuities in lead contacts at the T7 harness connector end. The test was resumed with connectors by-passed by direct wire connections to the indicating instrument. This weakness in the harness connector end has been resolved by design and vendor process changes.

The 1000-hour Mission Profile Test was completed on 12 October without further incident. The Post Test Performance Calibration was performed and no significant change was apparent in comparison to the Pre-Test Calibration.

Disassembly and inspection of Engine K-202 revealed no indications of unusual distress or damage. The impeller housing (magnesium) exhibited a light rub indication at centrifugal impeller rear tip location. Detail inspection and analysis are in progress as of the end of this reporting period.

JANUARY THROUGH MAY 1975

Detail inspection and analysis of engine components was completed on Engine K-202 and satisfactory condition of hardware was demonstrated, thus completing the 1000-hour Mission Profile Test Task. Report No. LYC 75-37 "2000-Hour Mission Profile Test Performed on T53-L-703 Engines K-201, K-202, and K-205" will be issued in early June 1975 and will constitute completion of action required under this project task.

d. 350-Hour Mission Profile Test

April Through August 1974

T53-L-13B (GFE) Engine LE 15264 is to be converted to the T53-L-703 configuration, re-designated as Engine K-205, and assigned to perform this task section.

Conversion was in progress as of the end of this reporting period.

September Through December 1974

Conversion to Engine K-205 was completed and the 350 hour Mission Profile Test was started in late September.

During the initial calibration testing, a significant power shortage was exhibited. Data study and parts inspection concluded that air loss in the internal compression cooling network was the cause, effected by excessive clearance in the aft compressor air seal. This excessive clearance was produced by a design dimensional oversight which resulted when manufacturing process change was made to the pre-swirl detail. It was also noted during this analysis that the metal ring which provides sealing between first and second gas producer nozzles exhibited insufficient expanding force to effectively seal at its outer diameter.

Engine K-205 was reassembled with desired aft compressor air seal clearance and added expanding force on gas producer nozzle seal ring (by addition of a second ring expander). Return to test and calibration now exhibited proper power levels and performance characteristics.

The 350 hour Mission Profile Test was completed 24 October. Performance calibration checks taken before and after this test showed no significant difference.

Disassembly inspection revealed generally excellent condition of all parts. This engine incorporated a steel impeller housing during this test and no tip rubbing of impeller vanes was apparent.

JANUARY THROUGH MAY 1975

The 350-Hour Mission Profile Test was successfully completed during the last reporting period. Report No. LYC 75-37 "2000 Hour Mission Profile Test Performed on T53-L-703 Engine K-200, K-201, K-202, and K-205 " will be issued in early June 1975 and will constitute completion of action under this project task.

TASK II - Flight Test Support

April Through August 1974

T53-L-13B (GFE) Engines LE 16866 and LE-16258 were converted to the T53-L-703 configuration and re-designated as Engines K-203 and K-204 respectively. Both engines have been accepted tested and were delivered to Bell Helicopter Company in this reporting period as scheduled.

T53-L-13B (GFE) Engine LE 15124 is in process of conversion to the T53-L-703 configuration and will be re-designated as Engine K-206. Delivery to Bell as the third flight test engine is expected to be made, as scheduled, at the end of September.

September Through December 1974

Conversion to Engine K-206 was completed in mid-August. During initial attempted acceptance testing, low power was exhibited. Corrections to compressor air seal and gas producer nozzle interseal improvement were made similar to those described for Engine K-205. The acceptance test was completed and delivery of Engine K-206 was made to Bell on 4 October.

Upon initial runup of Engine K-203, a fuel control contamination problem was discovered. Similar condition was found in the fuel control on Engine K-204. Both controls were returned to Lycoming and the contamination condition was found to have been caused by the inadvertant use of an improper type preservation oil at post acceptance test in preparation for shipment.

Transfer of the uncontaminated fuel control from Engine K-206 and timely transmittal of a second replacement control prevented any serious delay of the Bell Flight Test Program.

Flight testing of two aircraft, A/C 70-15936 with Engine K-203 and A/C 70-16055 with Engine K-204 is presently in progress.

JANUARY THROUGH MAY 1975

Lycoming Flight Test support effort was completed through May 1975 as contracted. During the support coverage period, Engine K-203 in A/ C-70-15936 completed 117 hours of flight operation and Engine K-204 in A/C 70-16055 completed 169 hours of flight operation. Flight test activities covered included sea level and altitude testing at Edwards Air Force Base, complete weapons system testing at Yuma, Arizona, altitude testing at Alamosa, Colorado, and comparative army flight evaluation testing at Ft. Hood.

TASK III - Sand and Dust Test

April Through August 1974

This task will be performed in November, as scheduled, using Engine K-200. A test specification for this program is in preparation.

September Through December 1974

A test speceification for this task was submitted and accepted. Engine K-200, after completion of the 450 hour Mission Profile Test, was supplied to perform this sand and dust test.

The test was begun in early December and completed on 19 December. Performance calibration data was taken before and after the sand ingestion and analysis and comparison is in progress.

The engine has been disassembledfor inspection, documentation, and analysis of the effects of sand in ingestion.

JANUARY THROUGH MAY 1975

Inspection and analysis of Engine K-200 was completed following the 10-Hour Sand Ingestion Demonstration Test. Report No. LYC 75-16 was transmitted 29 May 1975, constituting completion of this program task.

TASK IV - Altitude Performance Test

April Through August 1974

This task will be conducted on Engine K-201 which will be delivered prior to the December, 1974 - January, 1975 scheduled testing period. A test specification for this program is in preparation.

September Through December 1974

A test specification for this task was submitted and accepted. Engine K-201, after completion of the 200 hour Mission Profile Test, was reassembled, acceptance tested, and shipped to NAPTC on 14 November.

Testing was initiated on 18 December at NAPTC and is presently in progress.

JANUARY THROUGH MAY 1975

The Altitude Performance Test of Engine K-201 was completed in March 1975. The scope of the test was to demonstrate steady-state, transient and starting characteristics of the T53-L-703 engine model from sea level to 25,000 feet at flight conditions of 0 to 500 knots. Results demonstrated compliance with model specification requirements, and Report No. LYC 75-36 " Altitude Performance and Starting Demonstration Test" will be issued in early June 1975, constituting completion of activity of this program task.

TASK V - Military Qualification Testing

April Through August 1974

T53-L-13B Engines LE 21401 and LE 21403 (GFE) have been received and will be converted to the T53-L-703 configuration for use in performing this task. Testing is scheduled to begin in mid November and no reason for any delay can be foreseen at this time.

September Through December 1974

Conversion of T53-L-13B Engine LE 21401 to the T53-L-703 configuration was completed and this engine designated as K-207 is assigned to run the 150 hour Military Qualification Test using MIL-L-7808 oil and JP-4 fuel.

During the preliminary calibration testing of Engine K-207, a rubbing sound was detected at coast down. Cell investigation determined that the sound was caused by interference at the centrifugal impeller vane rear tips against the magnesium impeller housing.

The original test plan was to run one Qualification Test Engine with a magnesium impeller housing and the second with a steel housing. However, in view of the severity of the rub in Engine K-207, it was decided (in conjunction with AVSCOM) to replace the magnesium impeller housing and run both qualification tests with steel housings. The centrifugal impeller was also replaced in Engine K-207 in view of the visual rub indication on the original impeller vanes.

Qualification testing of Engine K-207 has been resumed and is presently in progress.

Conversion rework of the engine supplied for the second 150 hour Military Qualification Test has not yet been completed. It is anticipated that this engine (K-208) will commence testing during the second week of January 1975.

JANUARY THROUGH MAY 1975

The 150-hour qualification test of Engine K-207, using MIL-T-5624 grade I (JP-4) fuel and MIL-L-23699 oil, was completed on 20 January 1975. Test results demonstrated compliance with all model specification requirements. Component inspection after the test revealed satisfactory and acceptable conditions. Report No. LYC 75-27, 150-hour qualification test performed on T53-L-703 Engine K-207A, was issued and transmitted on 20 May 1975.

Conversion of T53-L-13B Engine LE 21403 to the T53-L-703 configuration was completed and this engine was designated as K-208 and assigned to run the second 150-hour qualification test. The test was conducted from 27 January to 10 February 1975 using MIL-T- grade II (JP-5) fuel and MIL-L-7808 oil. Test results demonstrated compliance with all model specification requirements. Component inspection after test revealed satisfactory and acceptable conditions, except for a rub at the centrifugal impeller rear tip location. This rub was considered unacceptable and required a penalty test to demonstrate acceptability of revised impeller tip clearances.

Engine K-202A was run for 60 hours to fulfill this penalty requirement, and satisfactory acceptability was demonstrated.

Report LYC 33, 150 hour qualification test performed on T53-L-703 Engine K-208A, which includes details of the penalty test of Engine K-202A, was issued and transmitted on 27 May 1975. The Military Qualification Task of this program is now completed.